
Paints and varnishes — Cross-cut test

Peintures et vernis — Essai de quadrillage



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2409 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This third edition cancels and replaces the second edition (ISO 2409:1992), which has been technically revised. The main changes are:

- the requirements for the adhesive tape have been changed;
- precision data have been added.

Paints and varnishes — Cross-cut test

1 Scope

This International Standard describes a test method for assessing the resistance of paint coatings to separation from substrates when a right-angle lattice pattern is cut into the coating, penetrating through to the substrate. The property measured by this empirical test procedure depends, among other factors, on the adhesion of the coating to either the preceding coat or the substrate. This procedure is not to be regarded, however, as a means of measuring adhesion.

Where a measurement of adhesion is required, attention is drawn to the method described in ISO 4624.

NOTE 1 Although the test is primarily intended for use in the laboratory, the test is also suitable for field testing.

The method described may be used either as a pass/fail test or, where circumstances are appropriate, as a six-step classification test. When applied to a multi-coat system, assessment of the resistance to separation of individual layers of the coating from each other may be made.

The test can be carried out on finished objects and/or on specially prepared test specimens.

Although the method is applicable to paint on hard (e.g. metal) and soft (e.g. wood and plaster) substrates, these different substrates need a different test procedure (see Clause 6).

The method is not suitable for coatings of total thickness greater than 250 µm or for textured coatings.

NOTE 2 The method, when applied to coatings designed to give a rough patterned surface, will give results which will show too much variation (see also ISO 16276-2).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1513, *Paints and varnishes — Examination and preparation of samples for testing*

ISO 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

IEC 60454-2, *Specification for pressure-sensitive adhesive tapes for electrical purposes — Part 2: Methods of test*

3 Apparatus

3.1 General

Use ordinary laboratory apparatus, together with the apparatus specified in 3.2 to 3.6.

3.2 Cutting tool

3.2.1 General requirements

It is particularly important to ensure that the cutting tool has a defined shape and that the cutting edges are in good condition. Suitable tools are described in 3.2.2 and 3.2.3 and shown in Figures 1a) and 1b).

A single-blade cutting tool (3.2.2) is the preferred tool in all cases, i.e. with all kinds of coating on both hard and soft substrates. The multi-blade cutting tool (3.2.3) is not suitable for thick ($> 120\ \mu\text{m}$) or hard coatings or where the coating is applied over soft substrates.

The tools described in 3.2.2 and 3.2.3 are suitable for manual use and, although this is the more usual method of use, the tool may be mounted on a motor-driven apparatus which gives more uniform cutting. The application of the latter procedure shall be subject to agreement between the interested parties.

3.2.2 Single-blade cutting tool

A single-blade cutting tool shall have a 20° to 30° edge and a blade thickness of $\left(0,43^{+0,03}_{-0,03}\right)$ mm as shown in Figure 1a).

When the cutting edge has worn to 0,1 mm it shall be reground.

3.2.3 Multi-blade cutting tool

A multi-blade cutting tool shall have six cutting edges spaced 1 mm, 2 mm or 3 mm apart [see Figure 1b)].

The width across the six cutting edges, a , shall be 5 mm for a tool which has a cutting-edge spacing of 1 mm, and 10 mm for a tool which has a cutting-edge spacing of 2 mm.

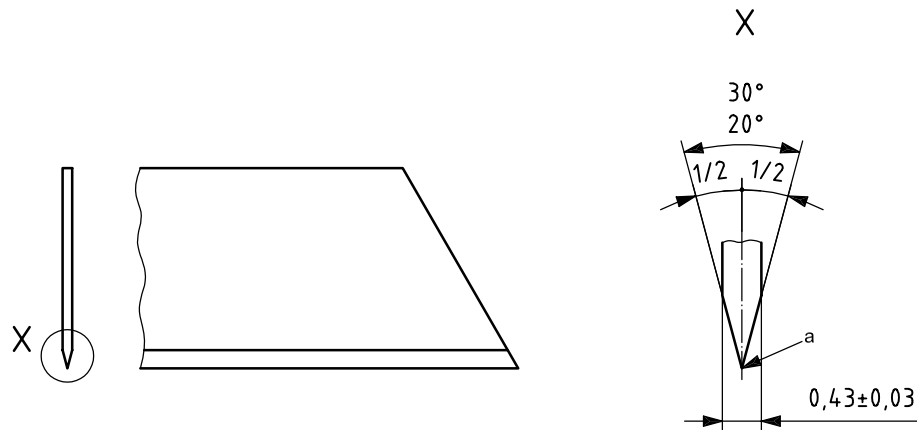
When the cutting edge has worn to 0,1 mm it shall be reground.

The guide edges and the cutting edges shall lie on the same diameter.

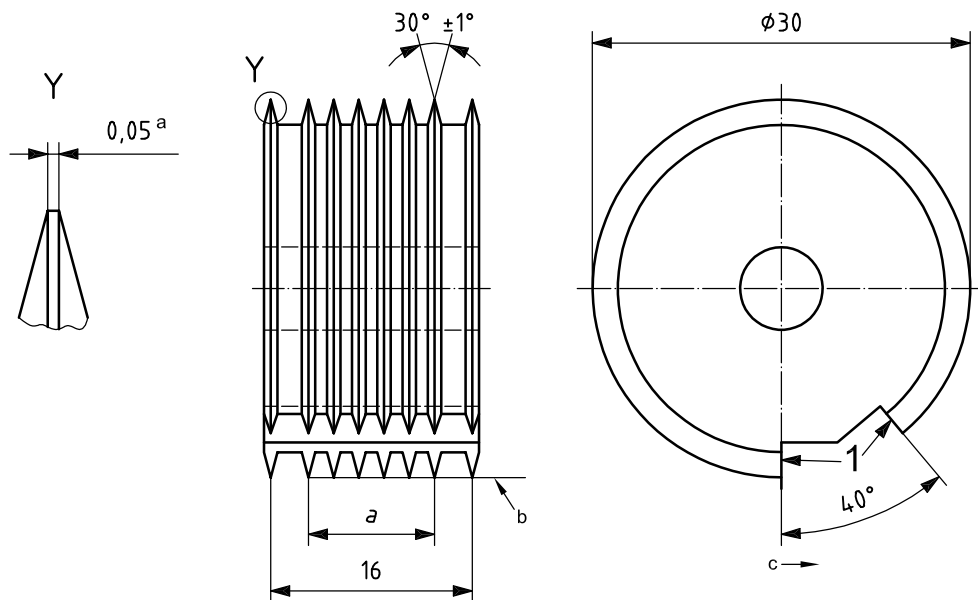
3.3 Guiding and spacing edges

In order to space the cuts correctly, a series of guiding and spacing edges is necessary when using a single-blade cutting tool. A suitable apparatus is shown in Figure 2.

Dimensions in millimetres,
except where indicated otherwise



a) Single-blade cutting tool

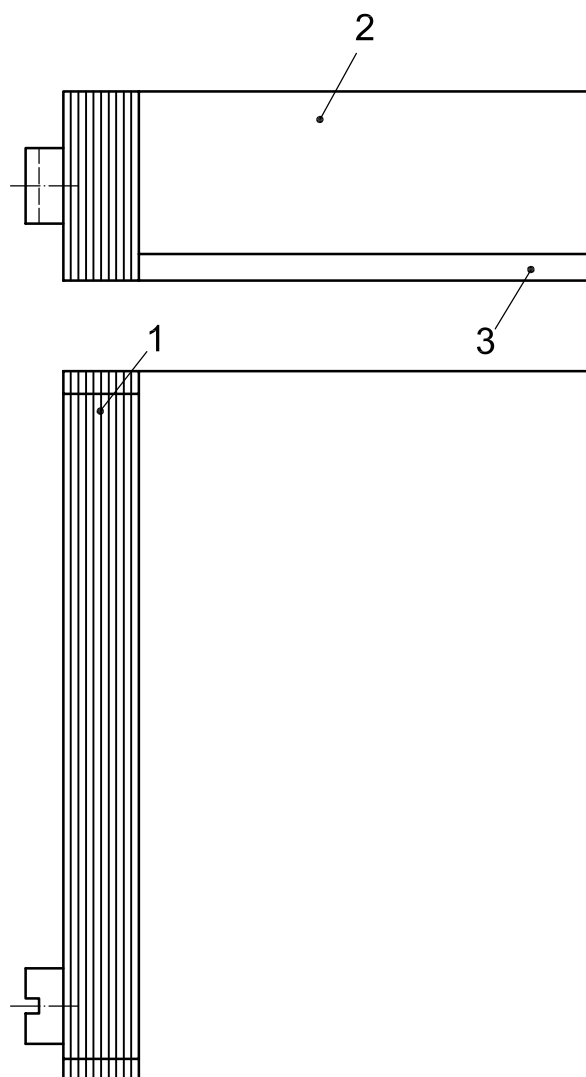


b) Multi-blade cutting tool

Key

- 1 cutting edges
- a width across all six cutting edges
- a Regrind when cutting edge has worn to 0,1 mm.
- b Guide edges and cutting edges lie on same diameter.
- c Direction of cut.

Figure 1 — Cutting tools



Key

- 1 ten spacing edges 1 mm thick
- 2 laminated moulding plastic or steel
- 3 rubber

Figure 2 — Series of spacing edges

3.4 Soft brush

3.5 Pressure-sensitive adhesive tape

Unless otherwise agreed, adhesive tape with an adhesive strength between 6 N per 25 mm width and 10 N per 25 mm width (determined in accordance with IEC 60454-2) shall be used. The tape shall be at least 50 mm wide.

NOTE Transparent tape is recommended.

3.6 Viewing lens

Use a hand-held lens with a magnification of $\times 2$ or $\times 3$.

4 Sampling

Take a representative sample of the product to be tested, as described in ISO 15528.

Examine and prepare each sample for testing, as described in ISO 1513.

5 Test panels

5.1 Substrate

Unless otherwise agreed, select the substrate from one of those described in ISO 1514.

The panels shall be plane and free from distortion. The dimensions shall be such as to allow the test to be carried out at three different positions not less than 5 mm from each other or from an edge of the panel.

Where panels consist of a relatively soft material such as wood, the minimum thickness shall be 10 mm. Where panels consist of a hard material, the minimum thickness shall be 0,25 mm.

NOTE 1 Rectangular panels, measuring approximately 150 mm × 100 mm, have been found to be convenient.

NOTE 2 In cases where the panel is made of wood, the direction and the structure of the grain can influence the test, and a pronounced grain will render the evaluation impossible.

5.2 Preparation and coating

Unless otherwise agreed, prepare each test panel in accordance with ISO 1514 and then coat it by the specified method with the product or system under test.

5.3 Drying

Dry (or stove) and age (if applicable) each coated test panel for the specified time and under the specified conditions.

5.4 Thickness of coating

Determine the thickness, in micrometres, of the dried coating by one of the procedures specified in ISO 2808. Make the measurement at, or as near as possible to, the positions at which the cross-cut is to be made. The number of thickness determinations is dependent on the method used.

6 Procedure

6.1 General

6.1.1 Test conditions and number of tests

Carry out the test at a temperature of $(23 \pm 2) ^\circ\text{C}$ and a relative humidity of $(50 \pm 5) \%$, unless otherwise agreed (see ISO 3270).

In field tests, the ambient conditions will have to be accepted.

6.1.2 Conditioning of the test panels

Unless otherwise specified, condition the test panels immediately prior to the test at a temperature of $(23 \pm 2) ^\circ\text{C}$ and a relative humidity of $(50 \pm 5) \%$ for a minimum of 16 h.

6.1.3 Number of cuts

The number of cuts in each direction of the lattice pattern shall be six.

6.1.4 Spacing of cuts

The spacing of the cuts in each direction shall be equal and shall depend on the thickness of the coating and on the type of substrate as follows:

up to 60 µm:	1 mm spacing, for hard (e.g. metal) substrates;
up to 60 µm:	2 mm spacing, for soft (e.g. wood and plaster) substrates;
61 µm to 120 µm:	2 mm spacing, for both hard and soft substrates;
121 µm to 250 µm:	3 mm spacing, for both hard and soft substrates.

The spacing of the cuts shall conform to the hardness of the substrate and the coating.

6.1.5 Number of determinations

Carry out the test in at least three different places (see 5.1) on the panel (see also Clause 8). If the results do not match, the differences being more than one classification unit, repeat the test at three other places, if necessary using different panels, and record all the results.

6.2 Cutting and removing the coating using the manual procedure

6.2.1 Place the test panel on a rigid, flat surface to prevent any deformation of the panel during the test.

6.2.2 Before the test, inspect the cutting edge of the blade and maintain its condition by sharpening or replacement.

Perform the cutting manually, following the specified procedure.

If the panel is of wood or similar material, make the cuts at approximately 45° to the direction of the grain.

6.2.3 Hold the cutting tool (3.2) with the blade normal to the test panel surface. With uniform pressure on the cutting tool and using the appropriate spacing guide (3.3), make the agreed number of cuts in the coating at a uniform cutting rate. All the cuts shall penetrate to the substrate surface.

If, because of the hardness of the coating, it is not possible to penetrate to the substrate, the test shall be declared invalid and so reported.

6.2.4 Repeat this operation, making further parallel cuts of equal number, crossing the original cuts at 90° to them so that a lattice pattern is formed.

6.2.5 Brush the panel lightly with the soft brush (3.4) several times backwards and several times forwards along each of the diagonals of the lattice pattern.

6.2.6 For hard substrates and for wood, apply additionally adhesive tape (3.5). If beginning a new series of tests, remove two complete laps from a reel of the adhesive tape and discard. Remove an additional length at a steady rate and cut a piece approximately 75 mm long.

Place the centre of the tape over the lattice in a direction parallel to one set of cuts as shown in Figure 3 and smooth the tape into place over the area of the lattice and for a distance of at least 20 mm beyond with a finger.

To ensure good contact with the coating, rub the tape firmly with a fingertip or fingernail. The colour of the coating seen through the tape is a useful indication of overall contact.

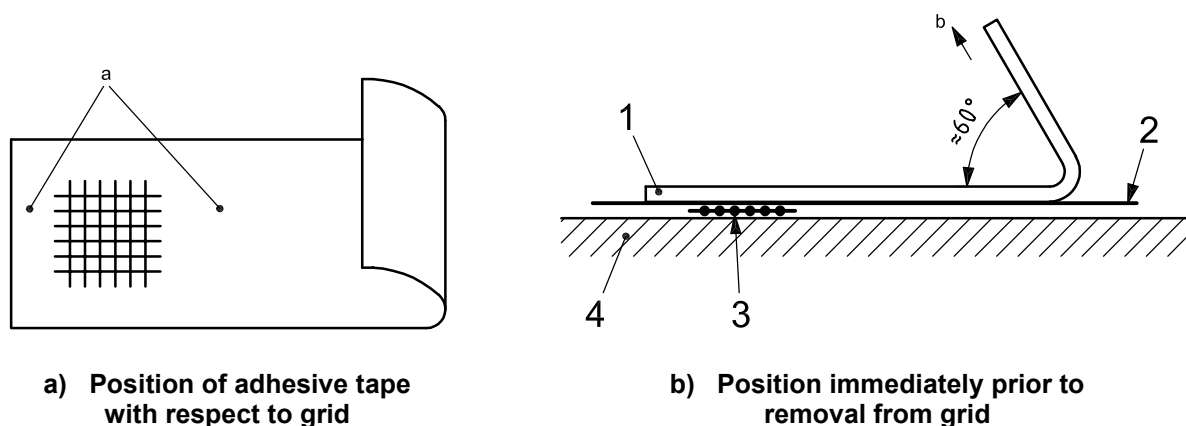
Within 5 min of applying the tape, remove the tape by grasping the free end and pulling it off steadily in 0,5 s to 1,0 s at an angle which is as close as possible to 60° (see Figure 3).

NOTE 1 Unless otherwise agreed, the operation of applying and removing the tape can be carried out more than once, depending on the kind of coating and the cutting direction (important with the use of the motor-driven tool — see 6.3).

NOTE 2 For coatings made up of more than one layer (e.g. automotive coatings), it is recommended that the tape application and removal operation be carried out at least once in each direction of the lattice pattern.

NOTE 3 For one-layer coatings, e.g. electrodeposited coats (E-coats), a single tape application and removal operation can be sufficient. However, for powder coatings, for instance, this is not sufficient.

NOTE 4 It is recommended that the tape be retained for reference purposes, for example by attaching it to a sheet of transparent film.



Key

- 1 tape
 - 2 coating
 - 3 cuts
 - 4 substrate
- a Smoothed down.
- b Direction of removal.

Figure 3 — Positioning of adhesive tape

6.3 Cutting the coating using a motor-driven tool

If the cutting tool is used with a motor-driven apparatus, take care that the points described in the manual procedure are observed, particularly with respect to the number and spacing of the cuts and the number of tests.

7 Supplementary test conditions

For any particular application of the test method specified in this International Standard, more details in addition to those in the preceding clauses might need to be given.

To enable the method to be carried out, the following information shall be supplied, as appropriate:

- a) the material, the thickness and the surface preparation of the substrate;
- b) the method of application of the coating material under test to the substrate, including the duration and conditions of drying between coats in the case of a multi-coat system;
- c) the duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing;
- d) the duration of conditioning of the test samples before starting the test (in the event of other tests having been performed beforehand on the same test specimens);
- e) the thickness, in micrometres, of the dry coating and the method of measurement used in ISO 2808, and whether it is a single coat or multi-coat system;
- f) the temperature and relative humidity, if different from those indicated in 6.1.1;
- g) the procedure to be carried out, i.e. whether it is a pass/fail or a classification test;
- h) the type of cutting tool used and the method of operation (manual or motor-driven);
- i) the performance required of the material in terms of the classification given in Table 1.

This information should preferably be agreed between the interested parties and may be derived, in part or totally, from an international or national standard or other document related to the product under test.

8 Evaluation and expression of results

Evaluate the results as follows:

- soft substrates: immediately following brushing;
- hard substrates and wood: immediately following removal of adhesive tape.

Carefully examine the cut area of the test coating in good lighting using normal or corrected vision or, if agreed between the interested parties, using a viewing lens (3.6). During the viewing process, rotate the panel so that the viewing and lighting of the test area are not confined to one direction. It can be useful to examine the tape in a similar manner.

Classify the test area in accordance with Table 1, by comparison with the illustrations.

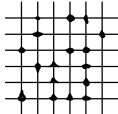
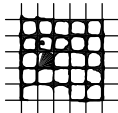
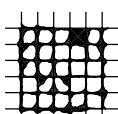
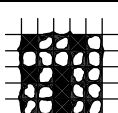
NOTE Additional guidance is given by the descriptions in Table 1.

In Table 1, a six-step classification is given. The first three steps are satisfactory for general purposes and are to be used when a pass/fail assessment is required. Special circumstances can arise, in which case the complete six-step classification will be necessary.

For a multi-coat system, report the interface at which any flaking occurs.

If test results differ, report each test result. In the case of a multi-coat system, report the site of separation (between coats or between coating and substrate).

Table 1 — Classification of test results

Classification	Description	Appearance of surface of cross-cut area from which flaking has occurred (Example for six parallel cuts)
0	The edges of the cuts are completely smooth; none of the squares of the lattice is detached.	—
1	Detachment of small flakes of the coating at the intersections of the cuts. A cross-cut area not greater than 5 % is affected.	
2	The coating has flaked along the edges and/or at the intersections of the cuts. A cross-cut area greater than 5 %, but not greater than 15 %, is affected.	
3	The coating has flaked along the edges of the cuts partly or wholly in large ribbons, and/or it has flaked partly or wholly on different parts of the squares. A cross-cut area greater than 15 %, but not greater than 35 %, is affected.	
4	The coating has flaked along the edges of the cuts in large ribbons and/or some squares have detached partly or wholly. A cross-cut area greater than 35 %, but not greater than 65 %, is affected.	
5	Any degree of flaking that cannot even be classified by classification 4.	—

9 Precision

9.1 Repeatability limit, r

The repeatability limit r is the value below which the absolute difference between two single test results, each the mean of duplicates, can be expected to lie with a 95 % probability when a method is used under repeatability conditions, i.e. when the test results are obtained on identical material by one operator in one laboratory within a short interval of time. For this test method, r is 1 classification unit.

9.2 Reproducibility limit, R

The reproducibility limit R is the value below which the absolute difference between two single test results, each the mean of duplicates, can be expected to lie with a 95 % probability when a method is used under reproducibility conditions, i.e. when the test results are obtained on identical material by operators in different laboratories. For this test method, R is 2 classification units.

10 Test report

The test report shall contain at least the following information:

- a) all information necessary to identify the product tested;
- b) a reference to this International Standard (ISO 2409:2007);
- c) the type of cutting tool used;
- d) the items of supplementary information referred to in Clause 7;
- e) a reference to the international or national standard, product specification or other document supplying the information referred to in d);
- f) the results of the test, as indicated in Clause 8;
- g) any deviations from the procedure specified;
- h) any unusual features (anomalies) observed during the test;
- i) the date of the test.

Bibliography

- [1] ISO 4624, *Paints and varnishes — Pull-off test for adhesion*
- [2] ISO 16276-2, *Corrosion protection of steel structures by protective paint systems — Assessment of, and acceptance criteria for, the adhesion/cohesion (fracture strength) of a coating — Part 2: Cross-cut testing and X-cut testing*

